Equivalent circuits corresponding to ideal dc-dc converter equations

Figs 3.2 / 3.3

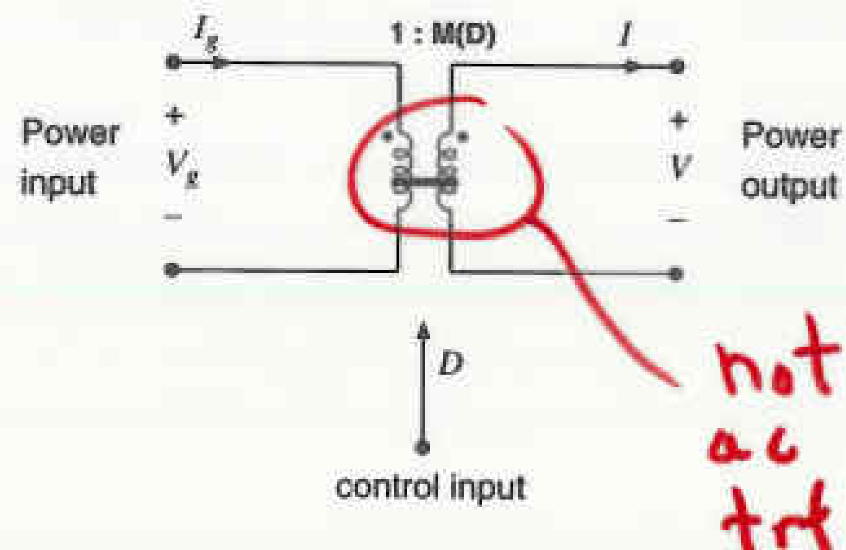
$$P_{in} = P_{out} \qquad V_g I_g = V I \qquad V = M(D)\, V_g \qquad I_g = M(D)\, I$$

Power Balance

$V_0 \downarrow I_0 \uparrow$ so that $\equiv V_g I_g$

dependent sources

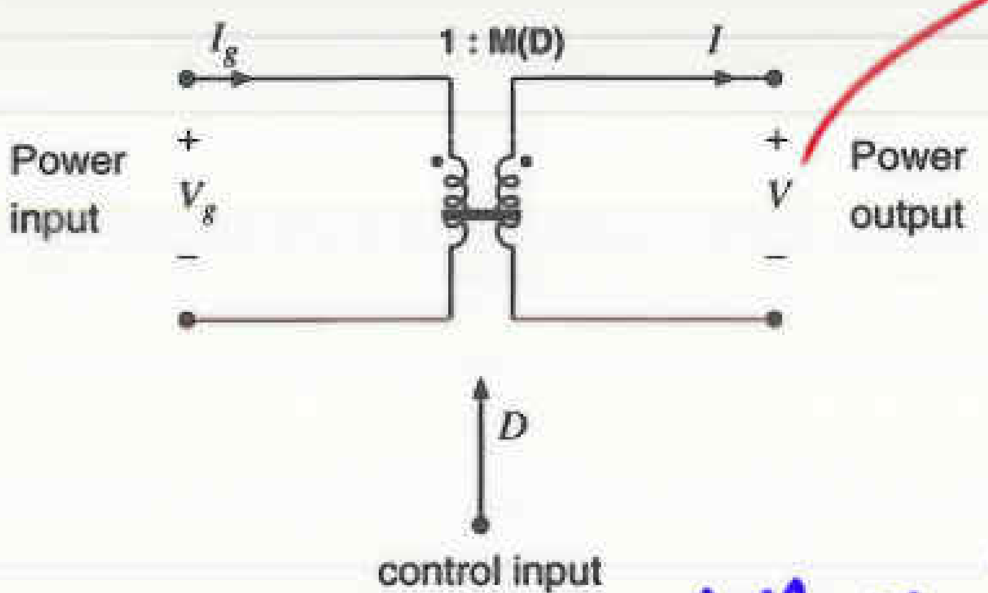
Dc transformer



The dc transformer model

Fig 3.3

Ch2 $V_{out} = f(D)$ only



Models basic properties of ideal dc-dc converter:

- conversion of dc voltages and currents, ideally with 100% efficiency
- conversion ratio M controllable via duty cycle

Why is $V_{out} \neq f(D)$ only?

$V_{out} = f(I_{load})$?

- Solid line denotes ideal transformer model, capable of passing dc voltages and currents
- Time-invariant model (no switching) which can be solved to find dc components of converter waveforms

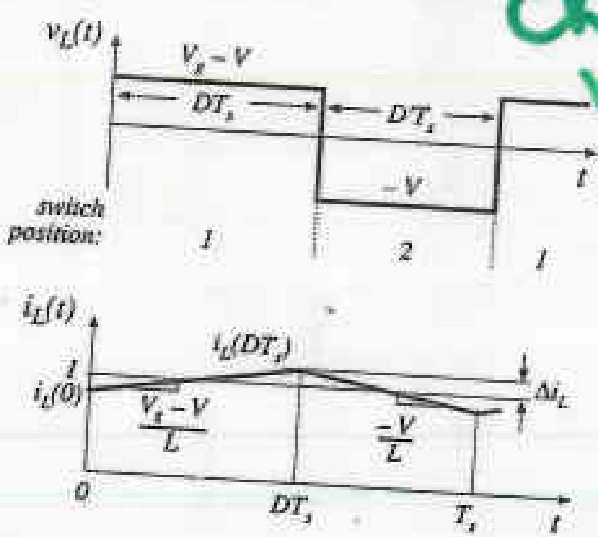
Part I. Converters in equilibrium

Ch 3 $\eta = f(D)$!

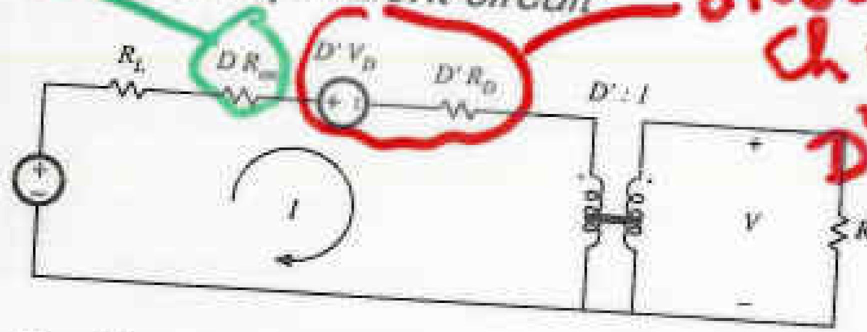
Overview of Loss & Efficiency

Tr sw loss on DC basis Ch 4 via D why?

Inductor waveforms

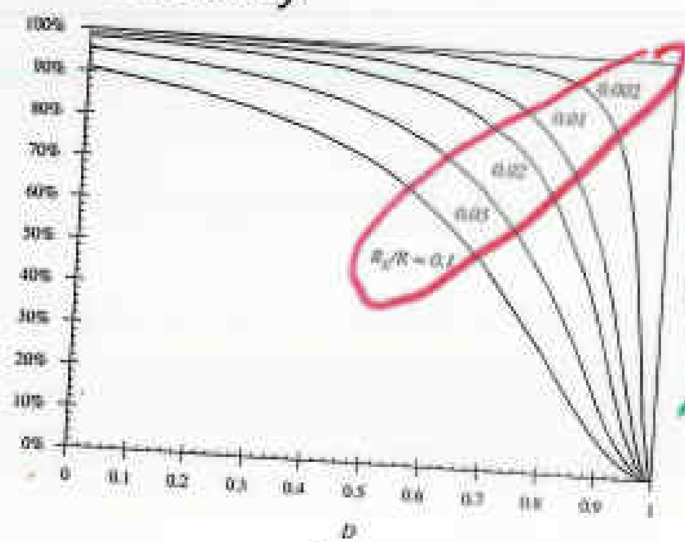


Averaged equivalent circuit



diode loss Ch 4 via D' why?

Predicted efficiency



Now $\eta(D)$

Discontinuous conduction mode – Ch 5

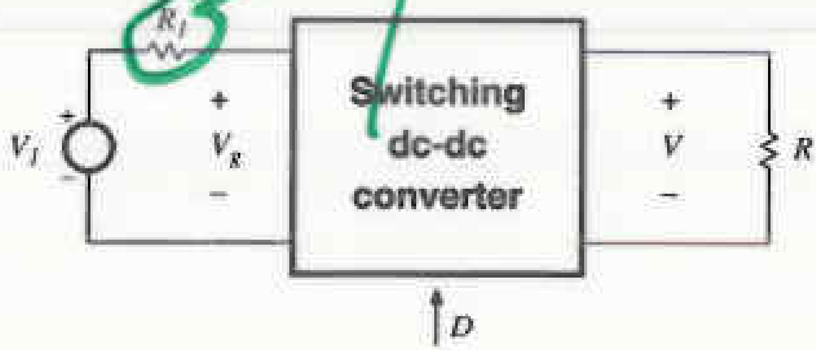
Transformer isolation ← Ch 6

Example: use of the dc transformer model

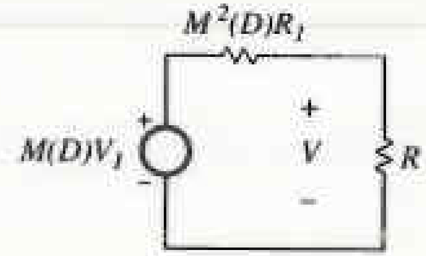
$M(D) = V_o / V_g = V_o / V_1$

Source R, wire R } 1st reality check

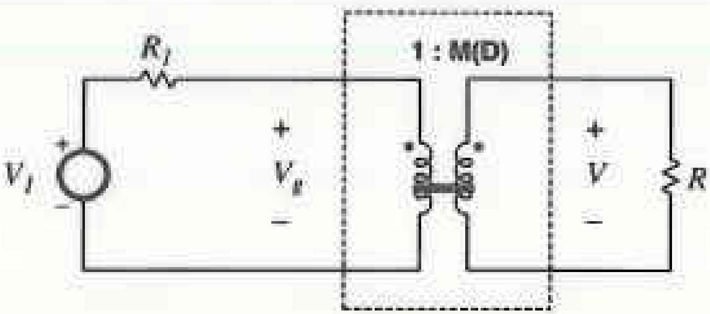
1. Original system



3. Push source through transformer



2. Insert dc transformer model



4. Solve circuit

$$V = M(D)\, V_1 \frac{R}{R + M^2(D)\, R_1}$$

still use old ideal V_{out}

Loss Effects due to R_{source} only

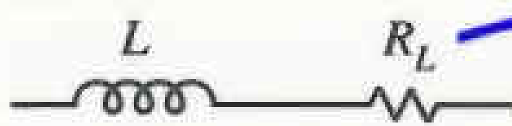
Pg 242 — 2nd reality — Limited Q

3.2. Inclusion of inductor copper loss

Follow $M(D,R) = M(D) f(R)$ ESR cases

Dc transformer model can be extended, to include converter nonidealities.

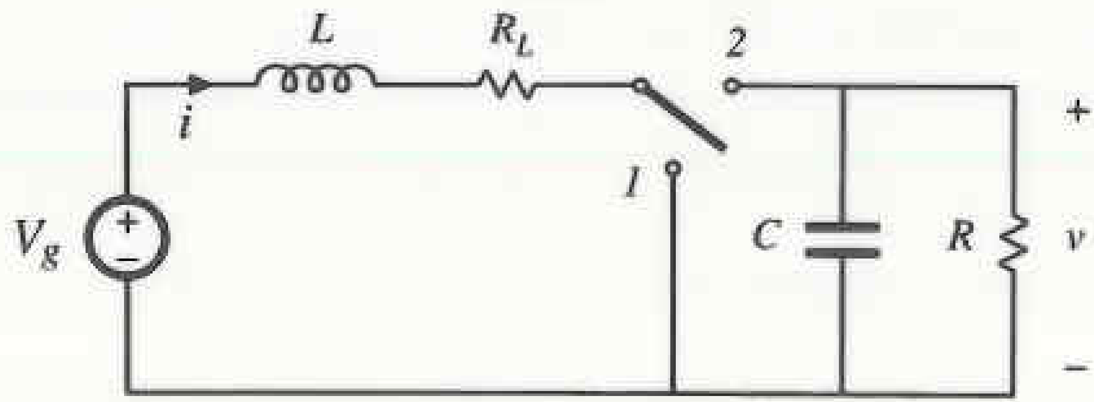
Example: inductor copper loss (resistance of winding):



Also core loss can be modeled

Insert this inductor model into boost converter circuit:

Fig 3.6



Boost Why?